5.16 Shoreline Erosion

5.16.1 Introduction

Erosion caused by TVA system operations occurs in both the reservoirs and the tailwater riverine sections. This section analyzes the impacts of reservoir operation alternatives on erosion in reservoirs and tailwaters, and provides a relative ranking of the impacts of the alternatives.

5.16.2 Impact Assessment Methods

Erosion in reservoirs is primarily influenced by wave energy affecting the shoreline and dislodging soil particles. Wave energy is derived from two sources: wind-generated waves and boat-generated waves. Wind waves are a function of the wind velocity and the distance, or fetch, at which the wave can build energy across the reservoir. Boat-generated waves in TVA reservoirs are due to recreational boat traffic and commercial activities, such as barge traffic. In general, commercial boat traffic is more prominent on TVA mainstem reservoirs than on tributaries.

Wave energy is particularly important to the shorelines at summer pool elevations; boat waves are more frequent due to summer recreational use and there are known critically eroded areas along the summer pool shoreline (see the description of TVA ALIS data in Section 4.16). It is anticipated that much of the shoreline considered "poor" in the ALIS data set has a vertical or steep bank that is vulnerable to wave action. Relatively gentle slopes distribute wave energy over a large area, while steep banks absorb all of the energy in a small area. If a reservoir is not held at a higher water elevation for as long a duration, these areas do not see as much wave action, and the wave energy is generally distributed over less abrupt slopes. If the reservoir is not filled as full, these areas never see wave action, and the waves generally only affect areas that have already eroded to a flatter slope. Conversely, if the reservoir is held at summer pool elevations longer, erosion effects are exacerbated.

Another form of erosion of concern in reservoirs is mass wasting. Mass wasting is the slumping, sliding, or toppling of sections of bank, caused by structural failure. An example of this is the slumping of cohesive, saturated soils from a steep embankment when water levels are rapidly dropped. Mass wasting can be facilitated by erosion of the shoreline at the toe of the slope or by undercutting of steep slopes. The resulting slope failure may often occur after drawdown.

Raindrops that land on exposed, unvegetated soils can initiate the erosion process by dislodging soil particles from the force of raindrop impact on the ground. This process is of concern to the TVA reservoir shorelines in the drawdown zone between summer pool elevation and winter pool elevation. This drawdown zone has been exposed to raindrop impacts for many decades. It is likely that where there is rocky soil or shallow soil over bedrock, most of these soils have already eroded. Unlike the summer pool elevations, erosion conditions of the drawdown zone have not been surveyed.

At winter pool elevations, wave energy also affects shorelines, which are often unvegetated bare soils. However, boat traffic typically is considerably less in winter than in summer. As with the drawdown zone, the winter pool shoreline conditions have not been surveyed.

Another factor affecting shoreline erosion is potential removal of vegetative cover from the shoreline. As discussed in the SMI EIS, healthy stands of woody and herbaceous vegetation around a riparian zone of a reservoir provide substantial protection of the shoreline from erosion. Development of the shoreline that would modify the shoreline vegetative cover would adversely affect erosion. Modification of shoreline vegetative covers from development was not a major consideration in this analysis for the following reasons. As described in Section 4.16, TVA has permit authority through Section 26A of the TVA Act to require erosion control measures for any shoreline development. In addition, TVA has designated a finite amount of shoreline land that is available for development. Although each of the policy alternatives may slightly modify the anticipated buildout date of the land available for development (see Section 4.15, Shoreline Development and Use), this change is not anticipated to affect the overall erosion conditions of the reservoirs.

Erosion in tributary tailwaters generally takes two forms. Surface erosion is the detachment and transport of surface material by flowing water that affects both the bed and the banks of a stream when they are exposed to flowing water. Mass wasting, as described above, can also occur in tailwaters when shoreline soils are saturated and water levels are rapidly dropped, especially in steep embankments.

Because mainstem tailwaters are essentially the upstream end of the next downstream reservoir, erosion in both reservoirs and mainstem tailwaters are influenced more by wave energy, whereas tributary tailwaters are primarily influenced by water flow forces. Therefore, separate analyses were conducted for reservoir and mainstem tailwater shorelines and for tributary tailwater shorelines.

The analysis conducted for this EIS considered the following elements to evaluate potential impacts of reservoir Operations policy alternatives. Three primary factors were evaluated:

- Duration of shoreline exposure to summer pool reservoir elevations. Longer periods at high pool levels would cause wave energy to exacerbate existing erosion.

- Changes in boat-wave energy from recreational boat activity and commercial barge operations. Longer periods at high pool levels would result in higher recreational boat traffic, which would accelerate the rate of erosion.

- Durations of high flows in tailwaters. None of the alternatives would increase existing maximum tailwater flows; however, alternatives that would involve longer durations at high flows would prolong high shear stress forces on streambanks, potentially resulting in increased erosion.

Other potential contributing factors that were considered include:

- Erosion of the drawdown zone between summer pool elevation and winter pool elevation due to raindrop impact forces on bare unvegetated soils and from mass wasting of saturated soils from the drawdown action;

- Erosion of the shorelines at winter pool elevations, which may erode bare unvegetated shorelines and may facilitate mass wasting by eroding the toes of slopes;

- Development of the shoreline—removal of vegetation on the shoreline can accelerate erosion; however, existing TVA policies and land management practices were anticipated to eliminate or render unsubstantial any differences in development-related erosion potential between the policy alternatives; and,

- Changes in reservoir surface area—higher reservoir levels create longer distances for wind energy to build up. None of the policy alternatives were anticipated to modify the surface areas of the reservoirs to the degree that a change in wind fetch would be measurable; therefore, this metric was not considered to be significant in the analysis.

Data used to evaluate the potential changes in erosion from the policy alternatives are summarized in the tables below.

Table 5.16-01 provides the durations that are projected for each representative reservoir to be held at summer pool elevation. The number of days at high pool elevations is an indicator of the relative impacts from wave energy on known existing eroded shorelines.

The durations of high flows in tailwaters are an indication of the degree that shear stress forces may dislodge soil particles from streambanks. Table 5.16-02 compares the projected median flows of the policy alternatives to the Base Case. The days exhibiting high flows are typically in spring, with minimal flows in late-spring-early summer, and some high-flow periods in fall. The projected flow curves did not show substantial variability in the alternatives; however, it is possible to generalize that an alternative would result in a higher or lower numbers of days that would experience high tailwater flows compared to the Base Case.

Table 5.16-01 Duration at High-Pool Elevations for Representative Reservoirs by Policy Alternative

Reservoir	Alternative							
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat
Tributary Reservoirs								
Chatuge	66	110	131	66	4	73	99	160
Douglas	88	106	128	44	0	66	117	153
Tims Ford	135	135	150	56	22	128	150	128
Normandy	NA	NA	NA	NA	NA	NA	NA	NA
Mainstem Reservoirs								
Fort Loudon	226	241	241	124	168	234	241	241
Nickajack[1]	–	–	–	–	–	–	–	–
Pickwick	190	252	248	131	190	190	245	252

Notes:
NA = Not available.
Values indicate the approximate number of days that median pool levels would be within 3 feet of the highest pool elevation.

[1] Elevations do not change across alternatives for run-of-river reservoirs.

Source: TVA file data.

Table 5.16-02 Comparison of Policy Alternative High-Flow Periods to Base Case for Representative Reservoirs

Reservoir	Alternative						
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat
Tributary Reservoirs							
Chatuge	Higher	Higher	Higher	Higher	Lower	Higher	Higher
Douglas	Higher	Higher	Higher	Higher	Similar	Higher	Higher
Tims Ford	Higher	Higher	Higher	Higher	Lower	Higher	Higher
Normandy	NA	NA	NA	NA	NA	NA	NA
Mainstem Reservoirs							
Fort Loudoun	Higher	Similar	Higher	Higher	Similar	Lower	Higher
Nickajack	Higher	Higher	Higher	Lower	Similar	Lower	Lower
Pickwick	Higher	Higher	Higher	Higher	Lower	Higher	Higher

Notes:
NA = Not available.
Entries refer to the relative amount (higher, similar, or lower) of high-flow days in tailwaters compared to the Base Case.

Source: TVA file data.

Projected changes in recreational use of the TVA reservoir system are discussed in Section 4.24, Recreation. Table 5.24-01 provides forecasted recreational use numbers in user days over the 35 TVA projects, and Table 5.24-02 provides an overall summery of the forecasts. The recreation analysis did not consider projections for each individual reservoir. The main recreational factor of interest for the erosion analysis is the overall projected changes in recreation use from the Base Case. Also of interest are the projected changes in recreational use below the dams (tailwaters). This information is summarized in Table 5.16-03.

Table 5.16-03 Summary of Change from Base Case in Recreation Use by Policy Alternative (August, September, and October)

	Alternative						
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat
Public access use below dams	Slight increase	Moderate increase	Large decrease	Large decrease	No change	Moderate increase	No change
Overall projected change	Large increase	Large increase	Large decrease	Slight increase	No change	Large increase	Large increase

The anticipated impacts of the Base Case and each of the policy alternatives are discussed in the following sections.

5.16.3 Base Case

The Base Case would result in continued erosion of reservoir shorelines and implementation of treatments and BMPs by TVA and others to improve shoreline conditions. Reservoir shorelines would continue to erode at their present rate, or potentially at a slightly accelerated rate due to projected increased recreational use.

As with reservoir shorelines, tributary tailwater streambanks would continue to erode under the Base Case at their present rate or potentially at a slightly accelerated rate due to projected increased recreational use.

5.16.4 Reservoir Recreation Alternative A

Duration at summer levels under Reservoir Recreation Alternative A would be substantially longer (up to 67 percent) in several of the representative reservoirs than under the Base Case, thereby increasing existing erosion. A large increase in recreational boating would also contribute to erosion of the shoreline.

Under Reservoir Recreation Alternative A, the reservoir drawdown curves would be sloped steeper to meet the existing curve, resulting in longer durations at high flows in tributary tailwaters and increased erosion. A slight increase in boat activity in the tailwater is also projected, which would increase erosion.

5.16.5 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Reservoir Recreation Alternative B would substantially increase the duration of high pool elevation in each of the representative reservoirs examined. A large increase in boat activity is also projected. Therefore, this alternative has high erosion potential. The Tailwater Recreation Alternative would also increase summer pool durations at each representative reservoir, but not to the degree of Reservoir Recreation Alternative B. Large increases in boat wave energy are also projected for the Tailwater Recreation Alternative.

Under Reservoir Recreation Alternative B, there would be longer periods of high flows in the tailwaters of the representative reservoirs tributary. This longer duration combined with a projected moderate increase in boating activity in the tailwater would increase the erosion in tributary tailwaters compared to the Base Case. Tailwater flows from some reservoirs would be higher under the Tailwater Recreation Alternative than under the Base Case and lower in other reservoirs. Because recreation boating is project to increase in the tailwaters under this alternative, there would be a higher erosion potential.

5.16.6 Summer Hydropower Alternative

The Summer Hydropower Alternative would result in shorter periods at summer pool levels than the Base Case and a consequent decrease in existing erosion. There would also be a large decrease in erosion from a corresponding decrease in recreational boating.

The potential for earlier drawdowns under the Summer Hydropower Alternative would allow for flatter drawdown curves from reservoirs than under the Base Case. However, because higher flow periods during the spring filling periods were found from a review of the flow curves for the representative reservoirs, it is likely that the tributary tailwaters would not see a substantial change from the existing conditions under this alternative.

5.16.7 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative generally would result in substantially shorter durations of high pool elevations than the Base Case. A slight increase in recreational boating activities is projected. The lower summer pool elevations and higher winter pool elevations would reduce the area of the exposed drawdown zone to rainfall impacts. Overall, this alternative would likely result in less erosion than the Base Case.

Under the Equalized Summer/Winter Flood Risk Alternative, the lower summer pool elevations and higher winter pool elevations would require flatter drawdown curves from reservoirs;

however, high flows in spring would be for longer durations at most representative reservoirs. Erosion in the tributary tailwaters would be similar to the Base Case.

5.16.8 Commercial Navigation Alternative

The Commercial Navigation Alternative is the only policy alternative that would result in significant changes to commercial boat traffic. This alternative, which enhances navigation in the mainstem by deepening the channel, would allow for barges to be loaded more fully. The heavier barges would have a deeper draft, which would send more wave energy to the shorelines. However, fewer trips are projected under this alternative. The reduction in trips would likely offset the increased wave energy from the heavier barges, and no significant change in erosion from the Base Case would be caused by commercial boat traffic.

Other erosion impacts under the Commercial Navigation Alternative would be similar to those described for the Base Case. The duration at high-pool elevation for each representative reservoir would be similar to the Base Case, and no change in recreational use is projected for the Commercial Navigation Alternative.

5.16.9 Tailwater Habitat Alternative

Summer water levels under the Tailwater Habitat Alternative would be at high pool elevations for substantially longer durations than under the Base Case, resulting in more erosion. A large increase in recreational boating would result in a corresponding increase in erosion.

Releases under the Tailwater Habitat Alternative would generally be at higher flows for longer durations than under the Base Case, resulting in increased erosion.

5.16.10 Summary of Impacts

Table 5.16-04 provides a summary of impacts on erosion by policy alternative. The Base Case would result in continued erosion of reservoir and tailwater shorelines, and implementation of treatments and BMPs by TVA and others to improve shoreline conditions. Recreational use of the TVA system is projected to increase under the Base Case; therefore, erosion may potentially be accelerated compared to the present rate. As described in the table, Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative are anticipated to increase the rate of erosion compared to the Base Case. The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative are anticipated to decrease the rate of erosion, while the Commercial Navigation Alternative is anticipated to cause similar erosion effects as the Base Case. Overall, none of the policy alternatives would result in a substantial change to existing erosion, except possibly the Tailwater Habitat Alternative.

Table 5.16-04 Summary of Impacts on Shoreline Erosion by Policy Alternative

Alternative							
Base Case	**Reservoir Recreation A**	**Reservoir Recreation B**	**Summer Hydropower**	**Equalized Summer/Winter Flood Risk**	**Commercial Navigation**	**Tailwater Recreation**	**Tailwater Habitat**
Continued erosion of reservoir and tailwater shorelines and implementation of treatments and Best Management Practices; the rate of erosion would potentially be slightly accelerated due to projected increased recreational use.	Substantially longer reservoir pool durations at summer levels, large increases in recreational boat waves, and longer durations at high flows in tailwaters than the Base Case would result in an increase in existing erosion.	Substantially longer reservoir pool durations at summer levels, large increases in recreational boat waves, and longer durations at high flows in tailwaters than the Base Case would result in an increase in existing erosion.	Shorter reservoir pool durations at summer levels and a large decrease in recreational boat waves than the Base Case would decrease existing erosion.	Substantially shorter reservoir pool durations at summer levels and a smaller drawdown zone affected by raindrop impact would result in less erosion than the Base Case.	Similar to the Base Case.	Similar reservoir pool durations at summer levels as the Base Case, but large increases in boat wave energy would result in an increase in existing erosion.	Substantially longer reservoir pool durations at summer levels, large increases in recreational boat waves, and longer durations at high flows in tailwaters than the Base Case would result in an increase in existing erosion.

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